Appendix A

State of California
Air Resources Board

Criteria Pollutant Emission Reductions from California's Zero-Emission Vehicle Standards for Model Years 2017-2025

Staff Report

Date of Release: July 6, 2021

This report has been prepared by the staff of the California Air Resources Board and approved by the Executive Officer for publication. At this time, this report has not been approved by a vote of the Board itself, and, accordingly, the views expressed herein should not be assumed to necessarily reflect those of the Board. In addition, the use of trade names or commercial products herein does not constitute endorsement or recommendation.

Summary

California has adopted requirements for zero-emission passenger vehicles for model years 2017-2025 as part of its Advanced Clean Cars (ACC) program. CARB analyzed three scenarios to estimate the emission benefits of these requirements:

- Estimates using the most recent version of CARB's emission inventory tool, EMFAC2021, that uses the most recent data and ZEV forecasting tools;
- Estimates using EMFAC2017, the version of CARB's emission inventory tool that U.S. EPA has approved for transportation and air quality planning under the Clean Air Act; and
- Estimates using EMFAC 2021 that estimate the benefits of manufacturer statements and California's policy directives to transition new passenger car and light-truck sales to zero-emission vehicles (ZEVs) by 2035.

All these scenarios show significant reductions in air pollution from the transition to ZEV technology. CARB has shown, including in implementation plans required under the Clean Air Act and approved by the U.S. Environmental Protection Agency, that a transition towards requiring nearly all new passenger vehicles to be zero emission is critical to attaining health and climate standards. California's authority to reduce emissions from vehicles is critical to meeting public health standards, including the National Ambient Air Quality Standards. Public health will improve dramatically if emissions from transportation-related combustion are nearly eliminated, through the proper regulatory course and in a reasonable time considering the costs and advancement of technology.

Analysis

ZEV Benefits Based on EMFAC2021

The first analysis uses the current version of CARB's on-road emission modeling tool, EMFAC2021,[1] to estimate the emission benefits of the ZEV requirements. EMFAC2021 uses the best available data and forecasting tools. These include the most recent available California Department of Motor Vehicle (DMV) population data and an updated market share projection that reflects recent policy and industry developments.

As one way of estimating the emission benefits of CARB's ZEV regulation for calendar years 2021, 2030, and 2035, CARB calculated the emissions benefits of the ZEV vehicles required under that regulation to illustrate that required ZEV sales have

[1] EMFAC is approved by U.S. EPA for planning required to meet the National Ambient Air Quality Standards. See 40 C.F.R. §§ 93.110, 93.111; 80 Fed.Reg. 77,337 (Dec. 14, 2014) [EMFAC2014 approval]; 84 Fed.Reg. 41,717 (Aug. 15, 2019) [EMFAC2017 approval]. EMFAC2021 is pending approval.

reduced harmful emissions in California to date and will continue to do so in the coming years. Results for calendar years 2023, 2031, and 2037 are also included to show the reductions needed for the South Coast air basin to attain the ozone National Ambient Air Quality Standards (NAAQS) by the applicable deadlines. These results are presented in Tables 1 through 6 below.

California's ZEV program for passenger vehicles is expected to result, by the end of 2021, in approximately 360,000 pure zero-emission electric vehicles (i.e., battery or fuel cell electric vehicles) and 200,000 plug-in hybrid electric vehicles of model year 2017 and newer operating in California. If these ZEVs instead had been equivalent model year gasoline vehicles, these vehicles would have emitted in calendar year 2021 an additional:

- 326 tons of NOx exhaust emissions,
- 366 tons of total organic gas (TOG) exhaust and evaporative emissions, and
- 16 tons of PM2.5 exhaust emissions

By the first key ozone NAAQS attainment year of 2023, the ZEV requirements are predicted to result in California having approximately 585,000 zero-emission electric vehicles and 308,000 plug-in hybrid electric vehicles of model year 2017 or newer operating on the State's highways. If those ZEVs were replaced with gasoline vehicles of an equivalent model year in calendar year 2023, they are estimated to emit an additional:

- 516 tons of NOx exhaust emissions,
- 538 tons of TOG exhaust and evaporative emissions, and
- 20 tons of PM2.5 exhaust emissions.

Looking forward to 2030, California's requirements for zero-emission vehicles are expected to result in approximately 1.4 million zero-emission electric vehicles and more than 600,000 plug-in hybrid vehicles of model year 2017 and newer operating in California. Substituting these ZEVs with equivalent model year gasoline vehicles is projected to result in calendar year 2030 of an additional:

- 1,122 tons of NOx exhaust emissions,
- 1,017 tons of TOG exhaust and evaporative emissions, and
- 27 tons of PM2.5 exhaust emissions.

By the second key ozone NAAQS attainment year of 2031, approximately 1.5 million zero-emission electric vehicles and 666,000 plug-in hybrid vehicles of model year 2017 and newer are projected to operate in California under the ZEV program. Replacing these ZEVs with equivalent model year gasoline vehicles in calendar year 2031 is projected to have an additional:

- 1,202 tons of NOx exhaust emissions,
- 1,081 tons of TOG exhaust and evaporative emissions, and
- 27 tons of PM2.5 exhaust emissions.

In 2035, CARB expects to see approximately 1.8 million zero-emission electric vehicles and 790,000 plug-in hybrid vehicles of model year 2017 and newer. If these vehicles were to be replaced with equivalent gasoline vehicles, they would have emitted in calendar year 2035 an additional:

- 1,476 tons of NOx exhaust emissions,
- 1,408 tons of TOG exhaust and evaporative emissions, and
- 26 tons of PM2.5 exhaust emissions.

By the third key ozone NAAQS attainment year of 2037, California's ZEV program is expected to result in approximately 2.0 million zero-emission electric vehicles and 837,000 plug-in hybrid vehicles of model year 2017 and newer. To substitute these ZEVs with equivalent model year gasoline vehicles, in calendar year 2037 they would have emitted an additional:

- 1,580 tons of NOx exhaust emissions,
- 1,579 tons of TOG exhaust and evaporative emissions, and
- 26 tons of PM2.5 exhaust emissions.

The methods used to calculate these estimates are described in the methodology section of this document, below. Tables 1 through 6 show the estimated emission benefits, separated by the major criteria pollutants from electric and plug-in hybrid vehicles, in years 2021, 2023, 2030, 2031, 2035 and 2037, separately.

ZEV Benefits Based on EMFAC2017

CARB also estimated the same emission benefits using the prior version of CARB's model, EMFAC2017. U.S. EPA has approved this model for transportation and air quality planning. This version estimates ZEV population under a minimum compliance scenario and does not reflect the significant increase in ZEV sales over the most recent model years. EMFAC2017 likely underestimates the actual benefits that will result from California's ZEV program, but was used as a comparison to the estimates using the updated data and forecasting tools and to provide an estimate using the model currently approved by U.S. EPA for use in planning under the Clean Air Act. These emission benefits are presented in Tables 7 through 12. In sum, by 2037, the ZEV standards will have avoided:

- 687 tons of NOx exhaust emissions,
- 915 tons of TOG exhaust and evaporative emissions, and
- 15 tons of PM2.5 exhaust emissions.

ZEV Benefits from 100% ZEVs

Finally, to fully underscore the magnitude of emission benefits ZEVs can achieve and the critical role they can play in meeting State and federal air quality and climate requirements, CARB estimated the emission benefits if the California fleet fully

transitions to zero-emission technology after model year 2025.[2] Staff's preliminary assessment, focused solely on emission benefits, shows that a full transition to the sale of 100% zero-emission passenger vehicles by 2035, with the criteria emissions standards[3] for internal combustion engines maintained in the interim, can lead to significant annual emissions benefits as presented in Table 13 of this document. The preliminary assessment only selected NOx, hydrocarbon (HC), and PM. In calendar year 2037, the increased sales of ZEVs in model years 2025-2037 would have avoided:

- 6,274 tons per year NOx exhaust emissions,
- 5,504 tons per year HC exhaust and evaporative emissions, and
- 861 tons per year PM exhaust and brake wear emissions.

To consider these reductions in context, NOx emissions in the South Coast air basin are approximately 278 tons per day as of calendar year 2021 for all mobile sources (annual average).[4] These emissions must be reduced to 141 tons per day to meet the 1997 ozone NAAQS of 80 parts per billion (ppb), which has a deadline of 2023. To meet the 2008 standard of 75 ppb, which has a deadline of 2031, NOx emissions must be reduced to 96 tpd. A significant portion of the reductions described above will occur in the South Coast air basin because of its high concentration of people, vehicles, and refineries; they are a significant part of the solution to meeting the air quality standards in California. Every reduction matters for meeting these health-based standards. (Other regions in California are also in non-attainment with federal air quality standards for ozone, and reductions of all sizes are likewise needed there, although the South Coast air basin faces the most significant ozone air quality challenge in the country.)

Methodology

The following assumptions and methodologies were used in the above analyses:

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[2] Automakers representing one-third of California's market have already announced targets for greater than 50% ZEV sales by 2030, as well as significant financial commitments to electrification and sustainability. See CARB, Advanced *May 2021 Advanced Clean Cars (ACC) Workshop Presentation*, May 6, 2021, slide 39. Governor Newsom, through Executive Order N-79-20, has also directed CARB to consider regulations to require all zero-emission new passenger car and truck sales in the State. CARB staff are developing the Advance Clean Cars II program focusing on post-2025 model year light-duty vehicles and are considering, in light of the current state of technology, where the next iteration of its ZEV standard will fall. This is an ongoing public process, and CARB welcomes participation from all stakeholders. For purposes of this analysis and commenting on U.S. EPA's proposal to reconsider SAFE 1, CARB provides the potential emission benefits of 100% ZEV sales by 2035 to illustrate how critical a role the ZEV standard can play in achieving requisite criteria and GHG emission reductions. This does not necessarily represent where CARB's ACC II program may end up.

[3] Assuming non-ZEV fleet will meet the 0.030 g/mi of HC+NOx standard.

[4] Based on CARB's CEPAM 2016 SIP Standard Emissions Tool *https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php*.

1. EMFAC2021 v1.0.1 and EMFAC2017 v1.0.3 *https://arb.ca.gov/emfac/emissions-inventory* are used to generate the default light-duty vehicle population and emission outputs. EMFAC2021 is based on the best available vehicle emissions and activity data, and reflects the most recent model development, emission standards, and adopted regulations in California. EMFAC2017 is the prior model version and has been approved by U.S. EPA in 2019 for use in state implementation plan development and transportation conformity in California.
2. For MY2017+, staff assumed the total light-duty vehicle population of pure electric and plug-in hybrid electric vehicles (PHEV) would be replaced with conventional or internal-combustion engine (ICE) gasoline vehicles. EMFAC2021 utilizes the historical vehicle registration data from the California Department of Motor Vehicles (DMV) to estimate California's vehicle population prior to 2019 and is using the best available forecasting methods (as described in the EMFAC2021 technical documentation[5]) to forecast the fleet population for years 2020 and onward.
3. In each model year, the light-duty car and truck categories had different vehicle technology group combinations to achieve the required fleet average emission standard, from about 0.091 g/mile in MY2017 to 0.030 g/mile in MY2025 and beyond. For the replaced vehicles, staff assumed that for each model year, the replaced vehicles will have the same emission rate in grams/vehicle/day per gasoline vehicle, which is calculated from the total estimated emissions of light-duty gasoline vehicles in tons/day for each pollutant, divided by the light-duty gasoline car and truck population for each 2017 and newer model year under the chosen calendar year using the default EMFAC2021 output. The replaced vehicles are not any specified vehicle type, but reflects the fleet average light-duty car and truck emission rate of each model year.
4. Using this information, the benefits of zero emission vehicles are calculated as:
$$Emissions\ Benefits\ (tons/year) = \{[Gasoline\ Vehicle\ Emission\ Rate\ (grams/vehicle/day) \times Total\ Electricity\ and\ PHEV\ Population) \div 907185\ (grams/ton)] - EMFAC2021\ PHEV\ Emissions\ (tons/day)\} \times 347\ (days/year)$$
5. Calendar Years 2021, 2023, 2030, 2031,2035 and 2037 are selected to demonstrate the approach. 2023, 2031, and 2037 are the deadlines for the South Coast air basin to attain the NAAQS for ozone. The emission benefits evaluated include NOx total exhaust emissions (NOx_TOTEX), total organic gas (TOG) total exhaust (TOG_TOTEX) and evaporative emissions (TOG_EVAP), PM10 (PM10_TOTEX) and PM2.5 (PM2.5_TOTEX) total exhaust emissions, separately. The TOG evaporative emissions will be calculated from the total

[5] See CARB, EMFAC2021 Volume III Technical Document Version 1.0.1 April, 2021, pp. 170-172, available at: *https://ww2.arb.ca.gov/sites/default/files/2021-04/emfac2021_technical_documentation_april2021.pdf*

TOG emissions (TOG_TOTAL) minus total TOG exhaust emissions (TOG_TOTEX).

6. Finally, for purposes of this analysis in illustrating potential emission benefits of a more aggressive scenario of all new passenger vehicle sales being zero-emission by 2035, staff assumes 1% of vehicle sales will be very-low emission engines as an artifact of remaining credit balances, and that about 20% of ZEVs will be plug-in hybrid electric vehicles. EMFAC2021 is used to generate emissions for the selected calendar years and results are compared with default results that do not contain this more aggressive scenario. Note that this is a preliminary assessment based on potential emissions reductions from the developing Advanced Clean Cars II program, and therefore both the numbers and assumptions are subject to change through the regulatory development process to ultimate adoption by CARB's Board. Any estimates of the emission benefits of proposed regulations will be based on the terms of those proposals.

Table 1. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2021 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,761,857	53,040	45,887	63.20	49.36	21.49	3.14	2.88
2018	1,664,054	91,971	46,925	88.32	70.36	28.22	5.24	4.82
2019	1,439,688	67,342	34,733	60.61	47.81	20.83	3.78	3.48
2020	1,130,389	65,310	33,970	54.08	41.95	17.67	2.74	2.52
2021	1,194,017	81,141	41,713	60.02	46.05	22.06	2.20	2.03
Total	***7,190,005***	***358,804***	***203,228***	***326***	***256***	***110***	***17***	***16***

Table 2. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2023 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,670,673	49,736	43,025	62.93	47.73	21.48	2.79	2.56
2018	1,601,896	88,001	44,810	90.71	69.58	28.50	4.75	4.37
2019	1,377,643	64,738	33,061	63.65	47.75	21.13	3.44	3.16
2020	1,083,871	62,723	32,594	58.22	42.25	16.81	2.49	2.29
2021	1,301,842	88,377	45,362	75.51	53.20	23.83	2.27	2.09
2022	1,506,367	117,592	57,049	89.90	61.70	27.16	3.15	2.90
2023	1,341,403	113,719	52,192	75.17	50.52	26.32	3.14	2.89
Total	***9,883,695***	***584,886***	***308,092***	***516***	***373***	***165***	***22***	***20***

Table 3. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2030 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,171,534	33,196	29,042	44.14	32.64	27.44	1.44	1.32

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2018	1,172,676	61,338	31,733	68.29	50.18	41.08	2.58	2.37
2019	1,060,740	47,916	24,787	52.92	37.11	32.40	1.98	1.82
2020	865,905	48,302	25,425	52.74	34.83	28.59	1.49	1.37
2021	1,071,287	70,581	36,650	74.81	46.56	21.47	1.41	1.29
2022	1,264,816	96,896	47,309	97.76	57.18	23.63	2.02	1.86
2023	1,298,428	108,549	49,978	102.48	56.10	25.50	2.33	2.14
2024	1,328,316	118,306	52,422	102.76	50.75	27.92	2.63	2.42
2025	1,372,397	128,913	55,600	100.16	43.19	29.16	2.97	2.73
2026	1,427,168	118,969	52,365	88.46	38.52	27.08	2.43	2.24
2027	1,453,913	126,340	54,553	88.82	39.95	28.84	2.13	1.96
2028	1,492,029	135,186	56,763	88.78	41.59	30.95	1.85	1.70
2029	1,519,090	142,232	58,351	86.24	42.37	32.65	2.01	1.84
2030	1,368,210	134,517	53,328	73.92	38.58	30.93	1.95	1.79
Total	***17,866,509***	***1,371,241***	***628,306***	***1,122***	***610***	***408***	***29***	***27***

Table 4. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2031 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,071,221	30,057	26,384	39.81	29.47	24.69	1.26	1.16
2018	1,092,974	56,594	29,425	62.97	46.23	37.70	2.29	2.11
2019	988,258	44,336	23,007	49.10	34.32	29.81	1.76	1.62
2020	820,271	45,591	24,024	50.09	32.90	26.83	1.36	1.25
2021	1,014,781	66,643	34,650	71.42	44.09	39.53	1.28	1.18
2022	1,219,075	92,965	45,454	95.33	55.19	22.56	1.87	1.72
2023	1,249,998	103,905	47,942	100.32	54.20	25.30	2.15	1.98
2024	1,293,112	114,771	50,923	102.62	49.87	26.95	2.46	2.26

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2025	1,330,016	124,459	53,759	100.34	42.49	29.38	2.77	2.54
2026	1,398,587	116,253	51,224	90.36	38.51	26.34	2.29	2.11
2027	1,430,048	123,999	53,590	91.90	40.29	28.19	2.02	1.86
2028	1,456,568	131,849	55,384	92.24	41.85	30.04	1.74	1.60
2029	1,495,012	140,282	57,490	91.74	43.32	32.06	1.91	1.76
2030	1,519,756	149,237	59,187	90.02	44.72	34.18	2.09	1.92
2031	1,374,436	135,129	53,570	74.20	38.74	31.07	1.96	1.80
Total	***18,754,112***	***1,476,072***	***666,013***	***1,202***	***636***	***445***	***29***	***27***

Table 5. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2035 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	676,018	18,043	16,106	23.09	17.25	33.62	0.65	0.60
2018	726,693	35,783	19,106	38.95	28.67	55.20	1.26	1.15
2019	687,254	29,611	15,619	32.40	22.56	46.16	1.02	0.94
2020	593,252	32,125	17,035	35.25	22.89	45.78	0.82	0.76
2021	763,839	49,217	25,714	53.44	32.37	28.52	0.82	0.75
2022	949,815	71,450	35,064	75.43	42.49	35.46	1.24	1.14
2023	1,007,414	82,698	38,295	83.75	43.63	41.23	1.48	1.36
2024	1,076,841	94,160	41,998	90.18	41.89	47.21	1.74	1.60
2025	1,138,154	104,886	45,573	92.67	37.32	52.93	2.02	1.85
2026	1,224,047	100,179	44,415	87.21	35.10	24.31	1.71	1.57
2027	1,272,643	108,812	47,308	92.50	37.91	26.50	1.54	1.41
2028	1,324,547	118,591	50,062	97.75	40.92	27.82	1.36	1.25
2029	1,363,588	126,851	52,199	100.94	43.24	29.85	1.50	1.38
2030	1,408,044	137,839	54,750	105.08	46.32	31.00	1.67	1.54

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2031	1,443,939	141,712	56,217	103.33	46.56	32.03	1.78	1.64
2032	1,474,914	145,038	57,478	100.29	46.40	32.92	1.89	1.74
2033	1,517,172	149,322	59,150	96.90	46.31	34.05	2.01	1.85
2034	1,547,365	151,962	60,264	91.38	45.47	34.81	2.12	1.95
2035	1,397,424	137,390	54,466	75.18	39.33	31.59	1.98	1.82
Total	***21,592,963***	***1,835,669***	***790,819***	***1,476***	***717***	***691***	***29***	***26***

Table 6. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2037 Estimated from EMFAC2021

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	496,490	12,805	11,577	15.97	12.01	64.42	0.43	0.40
2018	550,355	26,158	14,223	27.89	20.63	39.82	0.86	0.79
2019	533,639	22,371	11,924	24.04	16.78	34.41	0.72	0.66
2020	472,503	25,148	13,381	27.20	17.65	35.34	0.60	0.55
2021	623,338	39,603	20,738	42.62	25.72	56.18	0.61	0.56
2022	791,255	58,873	28,949	62.00	34.69	75.77	0.95	0.87
2023	859,063	69,900	32,419	71.10	36.66	34.43	1.16	1.07
2024	934,956	81,168	36,285	78.68	36.03	40.21	1.39	1.28
2025	1,004,667	92,104	40,092	83.01	32.89	45.94	1.64	1.51
2026	1,098,477	89,487	39,745	80.05	31.62	44.97	1.42	1.30
2027	1,161,921	98,760	43,043	87.01	34.91	49.85	1.29	1.19
2028	1,228,842	109,133	46,237	94.12	38.47	26.41	1.16	1.07
2029	1,277,774	118,001	48,731	99.25	41.33	28.65	1.29	1.19
2030	1,328,353	129,282	51,509	105.34	44.91	30.21	1.46	1.34
2031	1,371,458	133,851	53,251	105.74	45.80	31.42	1.57	1.44
2032	1,422,045	139,226	55,298	105.95	46.75	31.32	1.69	1.55

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	EMFAC Population PHEV	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2033	1,457,795	143,090	56,760	104.15	46.97	32.34	1.79	1.65
2034	1,488,416	146,383	58,007	101.04	46.79	33.23	1.90	1.75
2035	1,530,253	150,624	59,663	97.57	46.67	34.35	2.03	1.86
2036	1,559,736	153,184	60,748	91.93	45.80	35.09	2.13	1.96
2037	1,407,545	138,385	54,861	75.57	39.58	31.82	1.99	1.83
Total	***22,598,881***	***1,977,534***	***837,439***	***1,580***	***743***	***836***	***28***	***26***

Table 7. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2021 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,707,208	33,578	22.91	16.89	9.05	1.43	1.32
2018	1,789,432	35,247	22.79	16.74	8.07	1.62	1.49
2019	1,872,756	38,985	23.38	16.90	8.21	1.76	1.61
2020	1,925,463	52,245	28.34	20.20	10.43	1.75	1.61
2021	1,753,482	60,092	29.80	20.81	11.43	1.30	1.19
Total	***9,048,341***	***220,147***	***127***	***92***	***47***	***8***	***7***

Table 8. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2023 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,616,231	31,671	21.15	15.64	12.20	1.23	1.13
2018	1,720,501	33,770	21.41	15.77	9.71	1.42	1.30
2019	1,794,590	37,277	21.96	15.91	9.49	1.53	1.41
2020	1,848,275	50,157	26.83	19.10	11.36	1.53	1.41

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2021	1,910,812	65,516	32.22	22.38	13.85	1.29	1.18
2022	1,944,581	80,665	35.92	24.37	16.39	1.64	1.51
2023	1,755,829	84,326	33.59	22.07	16.51	1.78	1.63
Total	***12,590,818***	***383,383***	***193***	***135***	***90***	***10***	***10***

Table 9. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2030 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,127,802	21,739	13.53	9.94	22.75	0.63	0.58
2018	1,247,826	24,145	14.39	10.49	17.15	0.75	0.69
2019	1,367,976	28,097	15.75	11.25	18.50	0.86	0.79
2020	1,462,409	39,275	20.41	14.10	20.59	0.89	0.82
2021	1,558,158	53,180	26.18	17.24	25.61	0.78	0.71
2022	1,622,234	67,050	31.00	19.34	25.56	1.01	0.93
2023	1,689,450	80,927	35.43	20.38	27.64	1.27	1.16
2024	1,738,183	94,365	39.56	20.22	26.78	1.53	1.41
2025	1,802,153	109,068	44.20	19.35	28.12	1.83	1.68
2026	1,860,393	112,676	43.68	19.97	26.85	1.67	1.54
2027	1,907,670	115,617	42.76	20.46	25.86	1.42	1.31
2028	1,976,732	119,856	42.17	21.18	25.43	1.20	1.10
2029	2,028,476	122,928	41.03	21.73	25.00	1.27	1.17
2030	1,848,208	112,003	35.35	19.84	21.94	1.20	1.10
Total	***23,237,670***	***1,100,925***	***445***	***245***	***338***	***16***	***15***

Table 10. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2031 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	1,031,258	19,780	12.18	8.93	22.31	0.55	0.50
2018	1,161,484	22,389	13.22	9.61	17.08	0.67	0.62
2019	1,273,815	26,108	14.52	10.33	18.59	0.76	0.70
2020	1,384,461	37,139	19.21	13.19	21.03	0.81	0.74
2021	1,474,864	50,307	24.76	16.15	26.39	0.71	0.65
2022	1,561,296	64,477	29.96	18.44	26.61	0.94	0.86
2023	1,623,050	77,655	34.43	19.42	29.61	1.17	1.07
2024	1,689,278	91,649	39.34	19.55	31.31	1.43	1.31
2025	1,743,661	105,437	44.38	18.69	29.93	1.70	1.57
2026	1,820,926	110,206	44.49	19.53	28.42	1.57	1.45
2027	1,874,953	113,560	43.85	20.11	27.07	1.34	1.23
2028	1,929,773	116,958	43.09	20.68	26.16	1.12	1.03
2029	1,998,944	121,204	42.47	21.40	25.72	1.21	1.11
2030	2,050,376	124,257	41.31	21.94	25.27	1.28	1.18
2031	1,867,302	113,159	35.57	20.02	22.17	1.21	1.11
Total	***24,485,440***	***1,194,285***	***483***	***258***	***378***	***16***	***15***

Table 11. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2035 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	652,599	12,162	7.10	5.20	17.56	0.29	0.26
2018	769,029	14,457	8.14	5.89	13.95	0.37	0.34
2019	883,819	17,840	9.54	6.72	16.37	0.44	0.41
2020	998,159	26,544	13.36	8.98	19.30	0.49	0.45

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2021	1,106,549	37,627	18.33	11.54	25.89	0.45	0.41
2022	1,212,707	49,938	23.44	13.69	26.44	0.62	0.57
2023	1,303,587	62,189	28.66	14.99	31.17	0.79	0.73
2024	1,399,855	75,682	35.11	15.68	35.75	1.00	0.92
2025	1,483,341	89,365	42.68	15.60	39.60	1.23	1.13
2026	1,583,338	95,459	44.20	16.74	39.42	1.16	1.07
2027	1,658,048	100,064	44.80	17.59	38.17	1.01	0.93
2028	1,745,961	105,507	45.55	18.58	36.06	0.86	0.79
2029	1,816,999	109,879	45.62	19.36	31.19	0.93	0.86
2030	1,898,706	114,924	45.75	20.25	29.65	1.01	0.93
2031	1,960,815	118,770	45.21	20.90	28.32	1.08	0.99
2032	2,015,720	122,178	44.36	21.47	27.33	1.15	1.06
2033	2,084,769	126,417	43.65	22.18	26.84	1.23	1.13
2034	2,134,760	129,374	42.36	22.71	26.33	1.30	1.20
2035	1,940,276	117,582	36.40	20.68	23.05	1.22	1.13
Total	***28,649,038***	***1,525,960***	***624***	***299***	***532***	***17***	***15***

Table 12. Emissions Benefits from Electric and Plug-in Hybrid Vehicles in CY2037 Estimated from EMFAC2017

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2017	481,250	8,746	4.95	3.63	13.98	0.19	0.17
2018	581,085	10,704	5.86	4.24	11.38	0.25	0.23
2019	686,039	13,689	7.14	5.01	13.92	0.31	0.29
2020	794,431	20,995	10.37	6.92	16.88	0.36	0.33
2021	902,009	30,598	14.74	9.15	23.44	0.34	0.31
2022	1,008,751	41,440	19.40	11.09	24.22	0.47	0.43

Model Year	EMFAC Population Gasoline	EMFAC Population Electricity	Emissions Benefits (tons/year) NOx_Exhaust	Emissions Benefits (tons/year) TOG_Exhaust	Emissions Benefits (tons/year) TOG_Evap	Emissions Benefits (tons/year) PM10_Exhaust	Emissions Benefits (tons/year) PM2.5_Exhaust
2023	1,109,572	52,818	24.60	12.45	29.43	0.62	0.57
2024	1,213,438	65,480	31.22	13.32	34.67	0.80	0.74
2025	1,307,809	78,673	39.40	13.55	39.44	1.00	0.92
2026	1,419,113	85,441	41.74	14.81	40.37	0.96	0.88
2027	1,510,729	91,019	43.23	15.85	40.33	0.85	0.78
2028	1,614,479	97,340	44.83	17.03	40.20	0.74	0.68
2029	1,696,631	102,397	45.59	17.96	39.06	0.80	0.74
2030	1,785,659	107,911	46.32	18.95	36.88	0.87	0.80
2031	1,857,354	112,324	46.36	19.74	31.89	0.94	0.87
2032	1,939,813	117,417	46.46	20.63	30.29	1.02	0.94
2033	2,001,986	121,270	45.89	21.29	28.92	1.09	1.00
2034	2,056,690	124,666	44.99	21.85	27.90	1.16	1.07
2035	2,125,638	128,899	44.23	22.56	27.37	1.24	1.14
2036	2,174,905	131,809	42.88	23.07	26.83	1.31	1.21
2037	1,974,898	119,680	36.81	20.99	23.46	1.23	1.13
Total	***30,242,278***	***1,663,316***	***687***	***314***	***601***	***17***	***15***

Table 13. Annual Statewide Criteria Emissions Benefits of Full Transition to Zero Emission Vehicles under ACC II proposal[6]

Calendar Year	Annual Emissions Benefit (tons/year)* NOx (tpy)	Annual Emissions Benefit (tons/year)* HC (tpy)	Annual Emissions Benefit (tons/year)* PM (tpy)**
2030	1,483	1,341	235

[6] The scenario presents the ZEV sales requirements as well as fleet average criteria pollutant standards for non-methane organic gases and oxides of nitrogen (NMOG+NOx) that contribute to ozone pollution, for conventional vehicles. For this scenario staff assumes that by 2035, only

Calendar Year	Annual Emissions Benefit (tons/year)* NOx (tpy)	Annual Emissions Benefit (tons/year)* HC (tpy)	Annual Emissions Benefit (tons/year)* PM (tpy)**
2031	1,988	1,804	306
2035	4,697	4,155	667
2037	6,274	5,504	861

* For this assessment, staff calculated emissions benefit for total hydrocarbons (HC), and total particulate matter (PM). For the ACC II regulatory proposal, staff will provide emissions benefits in terms of total organic gases (TOG) and fine particulate matter (PM2.5).

* including PM emissions benefit from reduced brake wear as zero emission vehicles deploy regenerative braking systems.

1% of vehicle sales will be very-low emission engines as an artifact of remaining credit balances, and that about 20% of ZEVs will be plug-in hybrid electric vehicles and the rest will be battery electric vehicles.